Greenm.

Black Spn

Recd Feb. 10. 1870

Feb. 10 70. —

Dear Dr Greenhow

Thanks for your pamphlet on dust lungs which I got at breakfast ~~nevertheless~~ You have yet to explain why colliers now have less "black spit" ~~than~~ Cornish miners, & why that disease decreases with increased ventilation in coal mines) that I believe to be the fact

See R[illegible]

the Mines commission
for the source of
my ~~opinions~~ notions
on the subject
which are that.
the evil begins with
~~bad air~~ foul air —

Jan

Yours most truly

[illegible]

my present coal
Commission ~~[illegible]~~

wants

from your impression
what ~~heat = extr~~ limit
~~of~~ heat in damp air
~~in the~~ will limit
profitable labour in
deep mines. If you
have published ~~any~~
~~thing~~ on that subject
I should be ~~thankful~~ glad of

The subject is far too long to enter on fully in a note.

77 Upper Berkeley St
February 22nd 1870

My Dear Mr Campbell

I am sorry that I cannot give you any positive answer but when I was in Cornwall in 1860 I was informed that the Temperature in the United Consols Mine near Redruth was as high as 120° to 125°

I should think it impossible
for any one to work in
(a higher temperature
unless means could be
devised for cooling the
air. Even then the ma
only could short spell
and one constantly sup
plied with cold wate
from above ground.
There is no difficulty
according to the com
municated in the pa

I send you, in understanding why colliers' lungs less black spit than Cornish miners. The black spit is in proportion to the amount of unconsumed smoke and dust. In well ventilated mines the combustion being more perfect less smoke is evolved from lights and in blasting and what there is to

more quickly swept away in the current of air. Hence less chance of particles to inhale. The Cornish mines are ill ventilated and much smoke remains after explosions especially in fast-ends. But the small shallow coal mines near Wolverhampton are very ill ventilated and the effects is well shown in the beautiful plate in my paper. Believe me very faithfully yours

E Headlam Greenhow

THIRD SERIES OF CASES

ILLUSTRATING THE PATHOLOGY

OF THE

PULMONARY DISEASE

FREQUENT AMONG

CERTAIN CLASSES OF OPERATIVES EXPOSED TO THE INHALATION OF DUST.

BY

EDWARD HEADLAM GREENHOW, M.D.,

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, ETC.

REPRINTED

BY J. E. ADLARD, FROM THE PATHOLOGICAL TRANSACTIONS,

1868-69.

Feb 22. 1870 —

answered letter of 22d —

Says that he knows nothing of insides but that I imagine that the deposition of carbon in lungs may be analogous to the [illegible] lamp caused by lack of oxygen — the carbon which is exhaled as carbonic acid when a sufficiency of oxygen from lack of it may be deposited from blood in lungs. — Told him the Treatment of consumptives abroad [illegible] limit of 4000 feet [illegible] increase of temperature damp air and endurance of 98° + 1° in damp air

Black lungs from a case of colliers' phthisis.

I AM indebted to Mr. Thomas Underhill, of Tipton, in Staffordshire, for the specimens exhibited to the Society. They were taken from the body of a man aged about sixty-five years, who had worked in a coal mine from boyhood. At the time of his death he had been incapacitated from work for two years, during which time he had suffered from cough and shortness of breath, with occasional attacks of what was called bronchitic asthma. He had only come under the care of Mr. Underhill a month before his death, and was then much emaciated, but with the exception of dulness on percussion below the clavicles he presented none of the ordinary symptoms of phthisis. About ten days before death he suddenly spat up a considerable quantity of sputum closely resembling black paint, and continued doing so to the amount of four or five ounces daily until he died. He sank at last very rapidly.

The lungs, on being incised, exuded a large quantity of thick fluid containing amorphous black pigment. The spirit in which they were placed for preservation very soon had the appearance of being mixed with soot, and on boiling a portion of it with an equal quantity of strong nitric acid the colour underwent no change. Another portion, evaporated to dryness, left a black sooty looking deposit upon the walls of the test-tube, and at the bottom of the tube a small amount of brownish deposit, which burnt with a strong smell of animal matter. The sooty looking deposit, when boiled for a considerable time in a mixture of strong nitric and hydrochloric acids, underwent no perceptible change, but on being allowed to settle remained in the form of minute black granules at the bottom of the tube.

The upper part of the right lung had been firmly adherent to the parietes of the thorax posteriorly; it was generally of a black colour. The pleura was everywhere thickened, and presented in several places smooth yellowish-white patches, one of which formed a sort of hood, as it were, over the apex of the lung, and was about a tenth of

an inch in thickness, presenting, on section, a dense white appearance. The apex of the lung was solidified into a firm mass, somewhat larger than a walnut, cutting with a smooth section, and perfectly dry, and looking, when cut across, not unlike a piece of black india-rubber. Immediately below this mass of condensed lung was a large, irregular, ragged cavity, containing a quantity of black pulpy *débris*, in the midst of which was a detached piece of lung the size of a hazel-nut. A smaller condensed mass was situated at the root of the lung, identical in character with the larger one at the apex; the remainder of the lung was also perfectly black on section, but for the most part of a spongy texture. Many of the bronchial tubes appeared to be dilated and thickened, and their mucous surfaces injected; they mostly contained mucus blackened by intermixture with pigment. The bronchial glands were enlarged, dense, and perfectly black, and exuded when incised, an abundance of black fluid, which stained everything with which it came in contact. The general appearance of the lung, when recently divided across from the apex downwards, is well shown in the accompanying drawing (Plate I, fig. 1), but the consolidated apex looks duller and less glistening, and the hue of the whole lung less perfectly black than in the fresh specimen.

The left lung contained a large solid mass, occupying the greater part of its centre, and closely resembling the condensed portion at the apex of the right lung, being perfectly black, smooth, and dry on section, and presenting to the naked eye no trace of lung-tissue. This mass was sharply circumscribed, and was entirely surrounded by a layer of spongy inelastic lung-tissue, also nearly black in colour; the spongy layer exhibited on section dilated air-cells, and much resembled the lung-tissue of senile emphysema; scattered through this spongy portion were several opaque, greyish-yellow solid, nodules, from the size of a hemp-seed to that of a pea. The pleura corresponding to the solid mass was thickened, but moved freely over it in consequence of the layer of spongy lung-tissue intervening between them.

Sections taken from the most densely consolidated portions of either lung showed under the microscope only an abundance of black pigment arranged in masses and granules, greatly obscuring the natural tissue, which was so compressed that no definite normal structure could be seen in it. Sections taken from the somewhat less dense parts of the mass, in the centre of the left lung, presented

fibrous tracts, containing curved elastic fibre thickly studded with masses of black pigment, and representing probably collapsed lung-tissue. In other sections, taken from the borders of the condensed part of the lung, the walls of the air-cells were seen to be considerably thickened, and to contain much black pigment, generally arranged in masses and granules, as seen in the drawing (Plate II, fig. 1). Black pigment was also seen, apparently contained in cells, lying loose in the air-cell cavities; these latter sections were intersected by fibrillated tracts, closely set with elongated nuclei, which in some places passed into and were continuous with the walls of the air-cells. In the spongy portion of the lung-tissue the air-cells themselves were in many places blocked up with exudation-cells. The pleura was seen under the microscope to be much thickened; it contained a distinct layer of pigment-deposit immediately below the surface, and presented here and there, on its free surface, distinct small projections, or nodules loaded with black pigment. Black pigment, in the form of granules, was seen under the microscope pouring freely from sections of the lungs immersed in glycerine.

A small portion of one of the lungs, having been first dried at a gentle heat, was incinerated in a porcelain crucible over a gas jet for upwards of three hours, when it left nearly 13 per cent. of ash of a yellowish-brown colour. On boiling this ash in nitro-hydrochloric acid for upwards of an hour the greater part of it was dissolved, but there remained an insoluble residue, which on being exposed in a covered platinum vessel to the fumes of hydrofluoric acid, was entirely dissipated. Two separate experiments gave the following proportions as the result of these processes:—One hundred grains of dried lung left after complete incineration 12·92 grains of ash, and this ash on being boiled in the mixed acids left 4 grains of insoluble residue. Under the microscope this residue did not polarize light. The acid liquor contained an abundance of iron and alumina.

Remarks.—The specimens afford an unusually striking illustration of the condition of the lungs in fully developed cases of the disease known as "colliers' phthisis." The history of the present case resembles in its main features that of a French millstone maker, who died under my care in the Middlesex Hospital in the year 1865;[1] the more universal and intense discoloration of the lungs in this case being accounted for by the different atmosphere in which the man

[1] See 'Pathological Transactions,' vol. xvii, page 24.

had passed his working life. The disease had, no doubt, been primarily chronic bronchitis, excited by the inhalation of grit; but, by degrees, the substance of the lungs had become affected, probably from the penetration of grit into their tissues, and the morbid condition termed by Rokitansky interstitial pneumonia had been induced. The formation of the consolidated masses in the lungs and the general black pigmentation of the lung-tissue must have been very slow processes, going on insidiously long before the man was disabled from work. His last illness appears to have arisen from an accession of pneumonia, causing the blocking up of a large portion of the still pervious air-cells with the inflammatory deposit seen on microscopical examination.

Specimens of miners' and flax-dresser's lungs.

I. Lungs from a collier. Death from tubercular peritonitis.

I am indebted to Dr. Philipson, of Newcastle-upon-Tyne, for the specimens, which were taken from the body of a patient who died in the infirmary under his care in March, 1869.

The man was forty-two years of age, and had worked as a coal miner from boyhood. He had been in the infirmary in October, 1868, for pleurisy, and was then discharged convalescent. During his last illness the pulmonary symptoms were of secondary importance to the abdominal ones, and the expectoration was small in amount, frothy, and slate-coloured. He died of tubercular peritonitis, accompanied by great emaciation.

On *post-mortem* examination the lungs were found to be in a state of inflammatory engorgement. The pleuræ were much thickened and covered with false membrane. The left lung was contracted and smaller than the right. The apex was solidified, very dense in texture, and of a very dark colour; the rest of the lung, though denser than natural, was still spongy, but everywhere deeply pigmented. On being cut across, the lung was seen to contain numerous firm black nodules, from the size of a hemp-seed to that of a horse-bean. Many of these nodules resembled india-rubber in consistence, and cut with a dry smooth section. In the centres of most of them the orifices of divided bronchial tubes could be distinguished

with the naked eye, showing apparently that the process of consolidation had commenced immediately around these tubes. Many of the tubes in the centres of the solid nodules were filled with yellow cheesy matter. The lower lobe was of a uniform black colour; but in the upper lobe, which was also generally very dark, the pigment was chiefly arranged in small circumscribed deposits, which stood out from the level of the section. With the exception of these small projections from the surface, the section was mostly quite smooth.

The right lung was larger and less shrunken than the left. The apex was consolidated and extremely dense; the dense portion was smooth on section, and presented a deep black ground, studded with white and grey patches and streaks formed by transverse and longitudinal sections of thickened and dilated bronchial tubes, some of which were pervious, whilst others were blocked up with yellowish cheesy matter. The rest of the lung was also deeply pigmented, and contained, scattered throughout its substance, many solid nodules similar to those seen in the left lung and already described. There were also several opaque, yellow, cheesy deposits about the size of peas, each surrounded by indurated black lung.

A section taken from the indurated black portion of the apex of the right lung presented under the microscope tracts of fibro-nucleated tissue, thickly studded with small masses of black pigment. Where the black pigment was not deposited in such dense masses as to render the section quite opaque, the irregular black granules of which it was composed appeared to be arranged in a linear direction in the course of the fibres. The nuclei, which were very abundant, were round and oat-shaped. Portions of the alveolar structure of the lung were visible between the fibro-nucleated tracts. The cavities of the air-vesicles were filled up with masses of round nuclei, and in some places with epithelial and compound granular cells. Where small bronchial tubes were cut across they most frequently appeared closely surrounded by masses of black pigment. A section from the apex of the left lung showed the walls of the air-vesicles thickened and studded with black pigment, and their cavities filled with inflammatory cells. At one point a transverse section of a bronchial tube, large enough to be plainly visible to the naked eye, showed the inner wall of the tube quite free from pigment, but immediately outside the wall there was a dense deposit of black pigment, which appeared to surround the tube completely. In

sections taken from the spongy part of the lung the air-vesicles in some situations presented the normal appearance, whilst in others their walls were thickened and contained deposits of black pigment. In some of these sections also, transverse sections of small bronchial tubes were seen surrounded by dense pigment-deposits immediately outside their walls.

II. Specimen of colliers' black lung.

The man from whose body the specimen was taken died with pulmonary symptoms several years ago in the Edinburgh Royal Infirmary, and the specimen was sent to me, when quite fresh, by Dr. Grainger Stewart. It was generally of a black colour, and exuded, when I first received it, a copious black juice, which stained everything with which it came in contact. The pleura was thickened and mapped out by opaque white lines, surrounding deep black circular patches, probably corresponding to lobules of lung. On section the cut surfaces of the lung were smooth and thickly studded with deposits of black pigment, which were distinctly seen to be arranged round the bronchial tubes. Under the microscope the characters and arrangement of the pigment were seen to be identical with those I have described in former reports to the Society.

A portion of the lung, dried at a gentle heat, and then incinerated in a porcelain vessel over a gas jet, left a red-coloured ash, which, on being boiled in aqua regia, was partly dissolved. The insoluble residue, when examined under the microscope, was quite amorphous, and did not polarize light. It was entirely dissipated by exposure in a platinum vessel to the fumes of hydrofluoric acid, showing it to be silica. The acid liquid in which the ash had been boiled contained a considerable quantity of iron and alumina. The experiments were repeated a second time, and on each occasion gave the following results. One hundred grains of dried lung yielded 8·02 grains of ash, of which 4·27 grains were dissolved by boiling in the acids, leaving 3·75 grains of amorphous silica.

III. Specimen of lung from a man who had worked chiefly in copper mines.

The specimen was sent to me by Dr. Grainger Stewart, of Edinburgh. The lung was, both externally and internally, of a deep black colour, and exuded, when fresh, a black fluid resembling Indian ink, and full of minute black granules. The pleura was somewhat

thickened and opaque, and a distinct tract of black pigment was deposited in the subpleural connective tissue. The lung was dense in texture, but still contained air, and just floated in water. It cut with a smooth section.

On examination of thin sections of the lung under the microscope the walls of the air-vesicles were seen to be thickened, and to contain numerous deposits of black pigment disposed in masses and granules. Many cells containing black granules were found lying loose in the cavities of the air-vesicles, some of them well defined, and others apparently surrounded by granules of free pigment. The accompanying drawing by Mr. Henry Arnott (Plate II, fig. 4) represents a section of the lung as seen under the microscope. It was selected with the view of showing the arrangement of the tract of pigment in the thickened pleura, and does not show so well as some other sections the large quantity of pigment deposited in the walls of many of the air-vesicles. Plate II, fig. 5, represents a portion of the same section, as seen under a higher power, showing the pigment deposited in the interstitial tissue in much the same manner as in other specimens of lungs formerly exhibited by me to the Society.[1] Two of the pigmented cells are also seen lying loose in the cavity of an air-vesicle, one of them having a defined margin, the other apparently surrounded by free granules of black pigment.

Specimens of flax-dresser's lungs.

I. These specimens of lungs, which were sent to me in April, 1868, by Dr. Clifford Allbutt, of Leeds, were taken from the body of a man aged 40 years. There was no history of hereditary phthisis, and the cough and other lung symptoms from which the patient had long suffered were attributed to the inhalation of flax dust. Having at one time changed his employment these symptoms had greatly subsided, but they increased again when he returned to work in the flax mill, and he eventually died with symptoms of severe pulmonary disease.

On *post-mortem* examination the lungs were found to be dark coloured, and generally a little emphysematous; the apices were crepitant. There were no cavities in the lungs, but some well-defined, consolidated nodules were found, two of which, together with small pieces of the upper lobes of both lungs, were sent to me

[1] See 'Pathological Transactions,' vol. xvii, pp. 26, 35, 37.

for examination. The larger nodule was of the size and shape of a walnut, but flatter. It cut firmly and with a granular section, and was of a grey colour interspersed with black. Under the microscope the air-vesicles were seen to be filled with exudation-cells, abundantly intermixed with granular matter and oil-globules. The section was traversed by several fibrous bands, some of which appeared to encircle air-cells; the field was studded here and there with patches of black pigment of irregular size and shape. The section very closely resembled that of a potter's lung exhibited by me to the Society in 1866, and figured in vol. xvii of the Society's 'Transactions' (Plate IV, figs. iii and iv). The smaller nodule was of a red colour, and sections examined under the microscope appeared less freely intersected by fibrous bands than the section from the larger nodule. The air-vesicles were filled with red exudation, consisting of inflammatory cells and blood-corpuscles, and having the characters of the exudation met with in ordinary pneumonia. Sections taken from the apex of the lung were almost of a black colour, and were seen under the microscope to be intersected by fibrous bands containing black pigment within their substance. The walls of the air-cells were thickened, and some of the cells contained granular exudation without oil. Masses of black pigment of irregular size and shape were studded over the field in great abundance.

A portion of the lung, weighing about a drachm, was examined chemically in the following manner:—Having been first slowly dried in a covered vessel at a gentle heat, it was weighed and then exposed for several hours to a red heat in a porcelain crucible over a gas jet, until every trace of carbon had disappeared. The ash resulting from this process, after being carefully weighed, was boiled in aqua regia for upwards of an hour, and the residue undissolved by the acid was washed, filtered out, and weighed. The acid liquid was found to contain alumina and iron. The result of this experiment was that one hundred grains of the dried lung left on incineration 3·881 grains of ash, which again, after boiling in aqua regia, left an insoluble residue amounting to 0·277 of a grain. This residue, when exposed in a covered platinum vessel to the fumes of hydrofluoric acid, was entirely dissipated, and thus shown to be silica.

II. This specimen I also owe to the kindness of Dr. Clifford Allbutt, of Leeds. It was taken from the body of a man aged 43, who died in the Leeds Infirmary, under Dr. Allbutt's care, in

September, 1868. He had worked as a flax-dresser from early life, and for some time at the inferior kinds of flax, which are the most dusty. He twice discontinued his employment for a period on each occasion of two years. During the first of these intervals he appeared to recover his health entirely, and during the second he improved very much. Being obliged to return to work in order to keep himself and family, his pulmonary complaint on each occasion returned also, and he eventually died of it.

Post-mortem examination.—The right lung (that exhibited to the Society) had evidently been adherent, posteriorly and laterally, to the parietes of the thorax. The pleura, where not adherent, was thickened and opaque. The anterior border of the lung was elastic and emphysematous, but with this exception the whole organ from apex to base was much consolidated. On making a section through the lower and more consolidated lobe, the surface of the section for about two inches inwards from the pleura was granular and of a red colour, intermixed with black. Towards the centre of the lung the tissue was crepitant, and contained much more black pigment. The surface of the section in the granular part presented numerous minute orifices, which under the microscope were seen to consist of dilated and broken-down air-cells. This appearance was probably due to their having been emptied of the exudation with which the neighbouring air-cells were filled, by the washing of the spirit in which the specimen was kept. The walls of the air-cells appeared thickened, and contained masses of black pigment, and their cavities generally were filled up with exudation-cells, some of which contained black granules. In the consolidated part the branches of the pulmonary artery were plugged. The minuter branches of the bronchial tubes stood out from the surface of the section with unusual prominence, and appeared thickened. The emphysematous portion of lung near the anterior margin was more deeply pigmented than the consolidated part. Sections taken from the dark crepitant portion towards the centre of the lung, examined under the microscope, showed abundant deposits of black pigment in the interstitial tissue. These deposits were usually in masses, consisting apparently of agglomerations of small granules, but the adjacent tissue, and even the air-cells, usually contained granular cells, more or less completely filled with black pigment in free granules or larger masses. The deposits of pigment in the lung-tissue were sometimes arranged in the form of tracts, which appeared to follow the course of

blood-vessels, but more frequently the pigment seemed to be deposited around the minute bronchial tubes. The granular pigmented cells found in the air-cells were of various sizes, from the $\frac{1}{2500}$th to the $\frac{1}{10000}$th of an inch in diameter. Sometimes they lay singly, at others in groups of ten or twelve together, and were generally round, but sometimes only irregularly roundish in shape. In some of the sections ciliated columnar cells, containing black pigment, were also found lying loose in the interstices of the section.

The accompanying drawing by Mr. Henry Arnott (Plate II, fig. 6) exactly represents a section of the lung containing a small bronchial tube surrounded by masses of black pigment. The adjacent tissue is crowded with granular cells, many of which also contain pigment. Some of these pigmented cells were also seen lying loose in the bronchial tube, but were not distinctly visible at the same focus as the parts represented in the drawing. A few of the pigmented cells, both of the round and ciliated forms, as seen under a higher power, are also drawn to scale on the same paper (Plate III, fig. 7).

A portion of this lung was incinerated, and treated in the manner described in the previous case. The experiment yielded the following results:—One hundred grains of dried lung left 2·609 grains of ash, of which 2·139 grains were dissolved by boiling in the acids; the insoluble residue, amounting to 0·47 of a grain, was amorphous, and entirely dissipated on exposure to the fumes of hydrofluoric acid; the acid liquid contained both alumina and iron. The result of the chemical examination, therefore, agreed in the main with that obtained from the examination of the first specimen, but differed somewhat from it in the proportions of residue left by each process. These differences may, however, be very probably ascribed to the fact of the experiment having been tried upon a more solid specimen of lung in the first case than in the second.

Remarks.—The several above-described specimens of lungs very completely illustrate the pathological changes produced in those organs by the inhalation of mechanical irritants. The nature of the substance inhaled appears to be of secondary consequence as regards the ultimate result, excepting that the heavier and more penetrating kinds of dust, such as angular particles of grit, more speedily excite serious disease than the lighter kinds. Mechanical particles inhaled into the air-passages set up, in the first instance, more or less irritation of the bronchial membrane, which may entirely subside again if exposure to its exciting cause be discon-

tinued. On the other hand, a continuance of the mechanical irritation rarely fails sooner or later to induce those changes in the interstitial tissue of the lungs seen in the several specimens which I have exhibited to the Society on the present and former occasions.

The characters common to all these cases are that the pleura is generally somewhat thickened over a greater or less extent, and that pleural adhesions are frequent. The density of the lungs is generally more or less increased, and patches of consolidation of various sizes are found in their substance. Sometimes the greater part of a lobe is so consolidated, as in both lungs of the Tipton coal-miner (see page 1); but more frequently the consolidation is of smaller extent, and is distributed throughout the lungs in several, sometimes many, well-defined hard nodules, varying in size from a hemp-seed upwards to that of a walnut, or even larger. The consolidated tissue, whether forming small nodules or occupying the greater part of a lobe, cuts with a smooth dry section, and, unless where the orifices of divided bronchial tubes are visible, presents no resemblance to ordinary lung-tissue, all traces of the vesicular structure being obliterated. On section, the nodules are sometimes of an iron-grey or greyish-yellow colour, but more commonly black, or nearly so, from the abundant deposit of pigment in their tissues; in many cases they are seen with the naked eye, and in almost all cases with the microscope, to be intersected by bands or lines of fibrous tissue. When the smaller nodules are cut across, the orifice of a divided bronchial tube is generally seen in the middle of the nodule, showing apparently that the consolidation has commenced immediately around the tube. The bronchial tubes in the consolidated tissue are frequently dilated and thickened, and are seen, as in the flax-dresser's lung, No. II (page 9), to stand out prominently above the level of the cut surface, surrounded by a black dense case, consisting of the indurated and deeply-pigmented tissue immediately around the tubes. When the tube is of small size, it is only on close examination that its orifice can be discovered in the centre of the black projection. Even those parts of the lungs which are still crepitant are for the most part denser and less elastic than normal lung, and they are also very frequently traversed by fibrous bands or tracts similar to those seen in the nodules. In some specimens these tracts are narrow and not very visible to the naked eye, but in others they are broad and very obvious, as in the specimens of grinders' and colliers' lungs exhibited by me to the Society in

the year 1865 (‘Path. Trans.,’ vol. xvi, pp. 59 and 60). When cut into, the lungs usually exude more or less of a black fluid, which closely resembles Indian ink in appearance. This fluid is most abundant in the lungs of miners, from the crepitant portions of which it often pours out in large quantities. When evaporated to dryness, it leaves a black residue which is quite insoluble by boiling in strong nitro-hydrochloric acid.

The bronchial glands are for the most part much enlarged, very dense, and of a black colour. On section a black fluid usually flows from them similar to that which escapes from the lungs; but sometimes, though more rarely, they cut with a dry smooth surface.

Microscopical examination of sections taken from the more consolidated parts of the lungs shows the natural tissue to be so much compressed that only traces of the alveolar structure are visible, the whole being generally rendered more indistinct by the abundant deposit of pigment; thickened and dilated air-tubes can, however, often be distinguished. When the lung is less dense the walls of the air-cells are frequently seen to be much thickened, containing especially at their intersections deposits of pigment. Again, some portions of the lungs in every specimen I have examined have presented an almost entirely normal appearance, with the exception of more or less black discoloration. This discoloration is most general and intense in the lungs of miners, such as the coal- and copper-miners’ lungs which I have now exhibited to the Society; least so, as a rule, in the lungs of such operatives as grinders, stone-masons, and flax-dressers, though even in these it is sometimes very remarkable, as in the lungs of a stone-mason exhibited by me to the Society in the year 1865 (‘Path. Trans.,’ vol. xvii, p. 24).

On microscopical examination the black pigment is seen lying in the interstitial connective tissue in the form of small granules or of larger masses of irregular shape. Sometimes it is so densely arranged as greatly to obscure the view even in the thinnest sections. The deposits of pigment in the thickened air-cell-walls are well seen in the drawings made for me by Mr. H. Arnott from sections of coal- and copper-miners’ lungs. Dense layers of pigment are usually found in linear tracts corresponding to the interlobular septa, to the course of vessels and air-tubes and to the sub-serous connective tissue. The arrangement of black pigment round a small bronchial tube divided transversely is shown in Plate II, fig. 6. The same drawing shows that the pigment lies outside the proper tissue of the

tube, often leaving a clear space between the deposit of black pigment and the cavity of the tube. This fact is demonstrated even more clearly in the drawing of a section of lung discoloured with red oxide of iron, in which the bronchial tube has been divided longitudinally (Plate I, fig. 2). To this specimen I shall again refer. The course of a tract of black pigment in the sub-serous layer of the pleura is well seen in Plate II, fig. 4. A portion of a projecting nodule loaded with black pigment is seen at the upper edge of the drawing, but the projection is less prominent than in some sections I have examined from other lungs.

Black pigment is likewise often seen in cells, either free in the air-vesicles and bronchial tubes or in the pulmonary tissue itself. Such cells are also frequently found in the sputum; not only in that of operatives whose pulmonary disease has resulted from mechanical irritation, but also in the sputa expelled in cases of ordinary bronchitis. These cells vary in size from the 1000th to the 3000th of an inch in diameter, and contain sometimes only a granule or two of pigment, whilst at others they are crammed full. They generally appear round and well defined, but sometimes their shape is partially masked by granules of pigment lying round them (Plate II, fig. 5). More rarely ciliated cells of columnar epithelium also containing pigment are seen lying loose in the bronchial tubes.

The fibrous bands with which these lungs are intersected are undoubtedly the result of a new growth of connective tissue. Their appearance under the microscope is shown in the annexed drawings made for me by my friend Dr. Burdon Sanderson from a section taken from the apex of the Tipton collier's lung (Plate II, figs. 2 and 3). The band in this case was almost free from pigment, and was distinctly visible to the naked eye as a colourless tract, intersecting the consolidated black tissue seen on either side of it. Fig 2 shows the appearance of the branched connective tissue-corpuscles at the junction of the adventitious septum with the consolidated lung; in this portion of the lung some black granules are seen. Fig. 3 shows the appearance of the tissue near the central part of the band. Here the bodies of the connective tissue-corpuscles contain yellow pigment.

Various opinions have been entertained respecting the nature and origin of the pigment in cases of black discoloration of the lungs such as I have now described. The first observers of this morbid condition belonged to our own country, and they were unanimous in considering the pigment as of extraneous origin. So long ago as

1813 Dr. George Pearson [1] read a paper before the Royal Society "On the Colouring Matter of the Black Bronchial Glands and of the Black Spots in Lungs," in which he showed as the result of chemical experiment that this colouring matter consisted of carbon, and was indestructible by boiling in the strongest acids. Having observed that this black discoloration did not exist in the lungs of infants or young persons, and that lungs "usually become more dark coloured proportionately to their age," he inferred that "the charcoal in the pulmonary organs is introduced with the air in breathing, and consists of invisibly small particles of carbon suspended in the air," and "derived from the combustion of coal, wood, and other inflammable materials." These particles he supposed to "penetrate into the minute tubes and air-vesicles, from whence they are absorbed by the lymphatics and conveyed to the bronchial glands."

In the years 1831 and 1834 Dr. J. C. Gregory, of Edinburgh,[2] and Dr. Hamilton, of Falkirk,[3] published cases of black infiltration of lungs in coal-miners, in which the appearances described correspond very closely with those presented by the specimens now exhibited to the Society. Chemical examinations of the lungs described by Drs. Gregory and Hamilton, which were made respectively by Dr. Christison, of Edinburgh,[4] and by Mr. Graham, Professor of Chemistry in the Andersonian Institution, Glasgow,[5] in all respects confirmed Dr. Pearson's view of the extraneous origin of the black matter with which the lungs were pigmented. At that period the use of the microscope in pathological investigations was comparatively rare, but Dr. Hamilton publishes in his paper a very remarkable report by Mr. J. W. Jones of a microscopical examination made by him of a bit of the black lung. After saying that he could perceive no definite structure in the lung, inasmuch as the black colouring matter and the lung tissue formed a confused mass, Mr. Jones proceeds to describe the microscopical appearances of the black matter, which he says "existed in two different states. In the one it could be squeezed out along with the mucus of the lung; in the other it was contained in the interlobular tissue. On examining the matter squeezed out from the lung, I observed that it consisted entirely of globules much larger than those of the blood;

[1] 'Philosophical Transactions,' 1813, p. 159.
[2] 'Edin. Med. and Surg. Journal,' vol. xxxvi, p. 389.
[3] Ibid., vol. xlii, p. 297.
[4] Ibid., vol. xxxvi, p. 394.
[5] Ibid., vol. xlii, p. 323.

among these globules were numerous black bodies which appeared to be globules containing black particles in their coats." Mr. Jones thus pretty accurately describes the pigmented cells which are found abundantly in the lungs and sputum in all similar cases, and which are figured in Plate II, fig. 7, from a section of flax-dresser's lung.

Subsequently, nevertheless, these early investigations were very generally either forgotten or discredited, and the correctness of the view that the pigment in cases of black discoloration of the lungs is of extraneous origin was warmly contested by many, more especially German, pathologists of high reputation, who maintained, on the contrary, that the pigment was derived from the blood. Several years ago, however, from the results of my own examinations of miners' lungs, I arrived independently at the conclusion that, at least in the case of persons employed in mines, the black pigment with which their lungs are coloured is derived from the soot and smoke given off by lamps and candles, or evolved from the combustion of gunpowder used for blasting. Since that time similar examinations of the lungs of potters, stone-masons, and other operatives, and more particularly of the flax-dresser's lungs described in the present communication, have convinced me that in these cases also the colouring matter is derived from the inhalation of fine particles of carbon diffused in the atmosphere of workshops and dwellings.

Quite recently a series of careful physiological experiments have been made by Dr. Knauff, of Heidelberg, the results of which demonstrate conclusively that black pigment may thus be introduced into the lungs from without.[1] In order to determine whether it were possible for extremely fine particles of soot to penetrate into the tissue of the lungs, Dr. Knauff placed some dogs in a large roomy chest into which the fumes of a smoking oil-lamp were conveyed by a flue opening through the floor. The animals were kept in this atmosphere during periods varying from one day to three months, and remained in good health throughout the whole term of their detention. In a dog killed after having been kept only a single day in the smoke-chest the whole surface of the bronchial mucous membrane, even to the alveolæ of the lungs, was covered with carbonic deposit mixed with mucus. Those animals which had been

[1] 'Archiv für pathologische Anatomie und Physiologie und für klinische Medicin von Virchow,' Bd. xxxix, S. 442.

shut up in the chest for some weeks previous to being killed exhibited carbonic deposits in the deeper parts of the organs of respiration, and first in the lymphatic glands. Not one of the experiments had a negative result, and the amount of deposit found was in proportion to the length of time the experiment had lasted. The black particles in the parenchyma of the lungs were found to be either scattered apparently without definite arrangement, or else in more or less connected lines. Mostly, however, they were gathered into little round or oval heaps, and these heaps themselves formed lines which followed the course of the fibre of the lung-tissue, and, therefore, either the direction of the alveolar partition walls or that of the vessels. In animals which had been confined for several weeks in the smoke-chest a deposit of carbon was also invariably found below the pleura. Dr. Knauff further states that no similar deposits of carbon were found in the lungs of other animals of the same litters which had not been confined in the smoke-chest.

The results of these experiments made by Dr. Knauff demonstrate beyond doubt that fine particles of carbon evolved during combustion, and suspended in the atmosphere, can not only penetrate into the air-cells in the deeper parts of the lungs, but can also make their way into the connective tissue surrounding the bronchial tubes, the vessels and lobules of the lungs, and beneath the pleura. Any other equally fine particles of dust diffused abundantly in the air would obviously penetrate into the lungs in the same manner, but there are few substances either so widely diffused or so finely divided, and so intense in colour, as particles of soot, and consequently I have myself never seen the lungs generally discoloured with any other pigment.

Dr. Zenker, of Erlangen, has, however, lately published two cases in which red oxide of iron in very fine powder had been habitually inhaled during life, and in which the lungs were found after death to be of an intense tile-red colour.[1] The oxide of iron dust was used in the preparation of paper books made to contain leaf-gold, and during the process of rubbing the dust into the paper with felt the air of the small workroom was constantly so loaded with fine red powder as to acquire a visibly red hue. In the most striking of Dr. Zenker's two cases the patient, a woman aged thirty-one years, had worked for seven years in this atmosphere. Symptoms of pulmonary disease had shown themselves a year and a half before death,

[1] 'Deutsche Archiv für Klinische Medicin,' Bd. ii, S. 116.

but she had continued her work until within the last eight weeks of her life. The symptoms of her illness were similar to those in the cases of pulmonary disease of coal-miners, stone-masons, and other operatives which have come under my care; and, with the single exception of the different hue of the discoloration, the lungs were found after death in the same condition as those which I have exhibited to the Society. On being cut they exuded a thick red fluid, and their tissue was everywhere of a bright tile-red colour. Scattered throughout both lungs were numerous tough, fibrous nodules of roundish shape, varying from the size of a pin's head to that of a pea, besides some larger ones of irregular shape. On section these nodules were of a yellowish-grey colour, mostly sprinkled throughout with tile-red spots, but some of them presented also black spots, though of smaller size. Minute cavities, apparently the orifices of divided bronchial tubes, were frequently seen in the centres of these nodules. Part of the apex of each lung was full of these tough nodules closely compacted together, whilst another part was changed into a black indurated mass sprinkled with a few small red spots. In both apices below the black induration there were cavities about the size of a cherry, whose broken walls were covered with crumbling greyish-yellow or tile-red masses. Similar cavities of irregular shape were found in the other lobes, the largest being in the right lower lobe, of which it occupied the whole upper half. Chemical examination proved the red colour of the lungs to be due to the presence of oxide of iron dust, precisely resembling that used in the workshop in which the woman had been employed. It would be out of place here to give any further details of this remarkable case, which I think fully justifies Dr. Zenker's conclusion that it must set at rest any lingering doubts as to the fact of solid particles of dust being transmitted from the external air into the parenchyma of the lungs.

By the courtesy of Dr. Wilson Fox I am enabled to exhibit to the Society a thin section of this lung, together with a microscopical drawing of the same made for me by Mr. H. Arnott (Plate I, fig. 2), from which it will be seen that the deposit of red colouring matter in the interstitial connective tissue is arranged precisely in the same manner as the black pigment in the colliers' and flax-dresser's lungs. The existence of the small patches of black colouring matter mentioned by Dr. Zenker in certain parts of these red lungs does not, in my opinion, at all militate against the view that the black colour in the

cases I have described is due to the presence of inhaled soot. Wherever there is fire or flame, there more or less soot is evolved into the atmosphere, which, though usually invisible to the naked eye, is rendered evident by the smoky hue acquired by ceilings, curtains, &c. Dr. Zenker's patient had, of course, in common with all other persons, been exposed to inhale air containing fine particles of carbon, and therefore black colouring matter, though in much smaller quantity than the red, was found in her lungs, as it is found more or less in the lungs of all persons who have passed the period of youth. Moreover, it seems only reasonable to conclude that these fine particles of carbon find their way much more readily and more abundantly into the lungs of persons already suffering from chronic pulmonary disease. Hence, probably, the explanation of the unusually black colour of the lungs of stone-masons and other operatives, who have not been exposed like colliers to inhale air containing any unusual proportion of fine particles of soot.

DESCRIPTION OF PLATE I.

This plate represents specimens of Lungs affected by the inhalation of Coal-dust and Oxide of Iron.

Fig. 1. Represents the right lung of the Tipton collier divided in front from apex to base: drawn from the specimen by Mr. F. S. Gibson. (Page 2.)

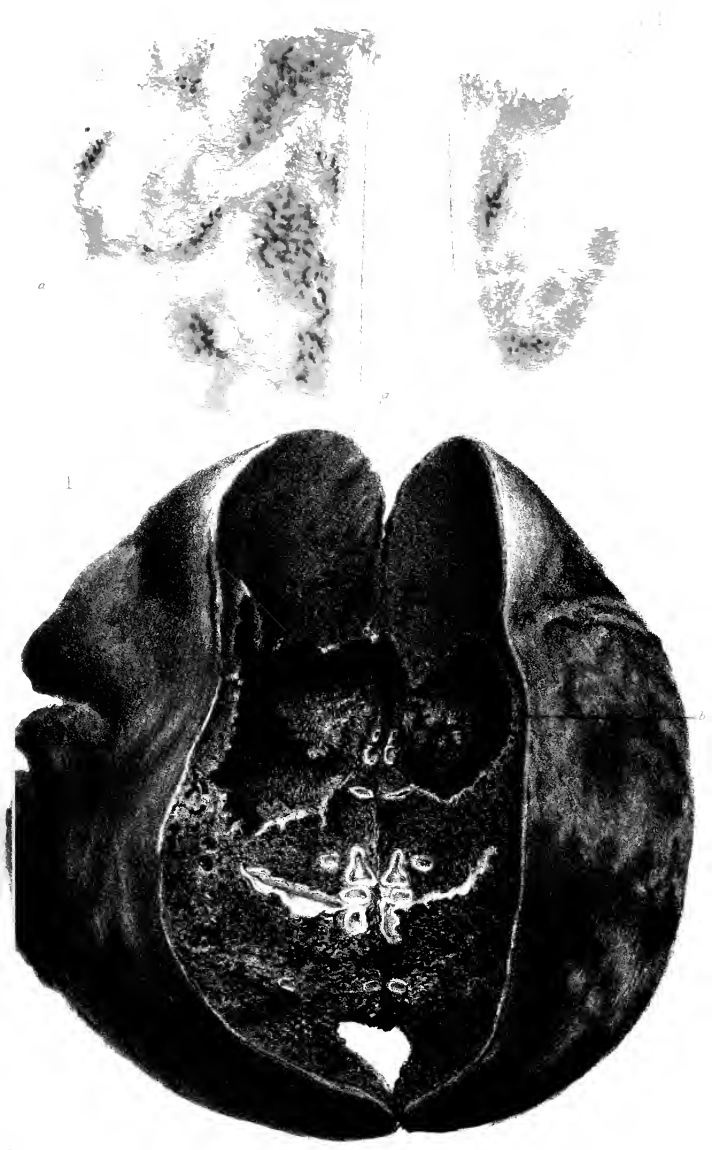
(*a*) Consolidated mass in apex of lung.

(*b*) Large cavity in centre of lung.

Fig. 2. Represents the microscopical appearance of a section of lung coloured with red oxide of iron, magnified 40 times: drawn by Mr. H. Arnott. (Page 17.)

(*a*) Oxide of iron deposited in the interstitial tissue of the lung.

(*b*) Bronchial tubes, showing a distinct uncoloured space between the cavity of the tube and the deposit of red colouring matter.



DESCRIPTION OF PLATE II.

The plate represents Specimens of Colliers', Miners', and Flax-dressers' Lungs. Figs. 2 and 3 were drawn from the microscopical sections by Dr Burdon Sanderson, F.R.S., and Figs. 1, 4, 5, 6, and 7, by Mr. Henry Arnott.

Fig. 1. Represents the thickened walls of the air-vesicles, seen in a section taken from the upper lobe of the Tipton collier's lung, at a part adjoining the condensed tissue. Magnified 200 diameters. (Page 3.)

(*a*) Deposits of amorphous black pigment.

Fig. 2. Shows the branched connective-tissue-corpuscles of an adventitious septum in the upper part of the same lung. Magnified 460 diameters. (Page 13.)

Fig. 3. Shows the tissue near the centre of the same septum, as seen in a longitudinal section. Magnified 460 diameters. (Page 13.)

Fig. 4. Section of copper-miner's lung. Magnified 40 diameters. (Page 7.)

(*a*) Thickened pleura, with deposits of amorphous black pigment in the sub-serous tissue.

(*b*) Part of a projecting nodule on the surface of the pleura, filled with black pigment.

Fig. 5. Part of the same section, magnified 200 diameters, showing deposits of black pigment in the interstitial tissue. (Page 7.)

(*a*) Two cells, containing black pigment, lying loose in the cavity of an air-vesicle.

Fig. 6. Section of flax-dresser's lung, magnified 30 diameters, showing a small bronchial tube surrounded by masses of black pigment. (Page 10.)

Fig. 7. Cells, containing black pigment, from the bronchial tubes of a flax-dresser. Magnified 200 diameters. (Page 10.)

(*a*) Round granular cells.

(*b*) Ciliated columnar cells.

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